(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 March 2002 (07.03.2002)

PCT

(10) International Publication Number
WO 02/19534 A1

(51) International Patent Classification⁷: H03M 7/04

(21) International Application Number: PCT/KR01/01399

(22) International Filing Date: 17 August 2001 (17.08.2001)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
2000/0048458 17 August 2000 (17.08.2000) KR

(71) Applicant and
(72) Inventor: LEE, Ho-Kyu [KR/KR]; 71-18 Hyomok-Dong Dog-Gu, Daegu 701-030 (KR).

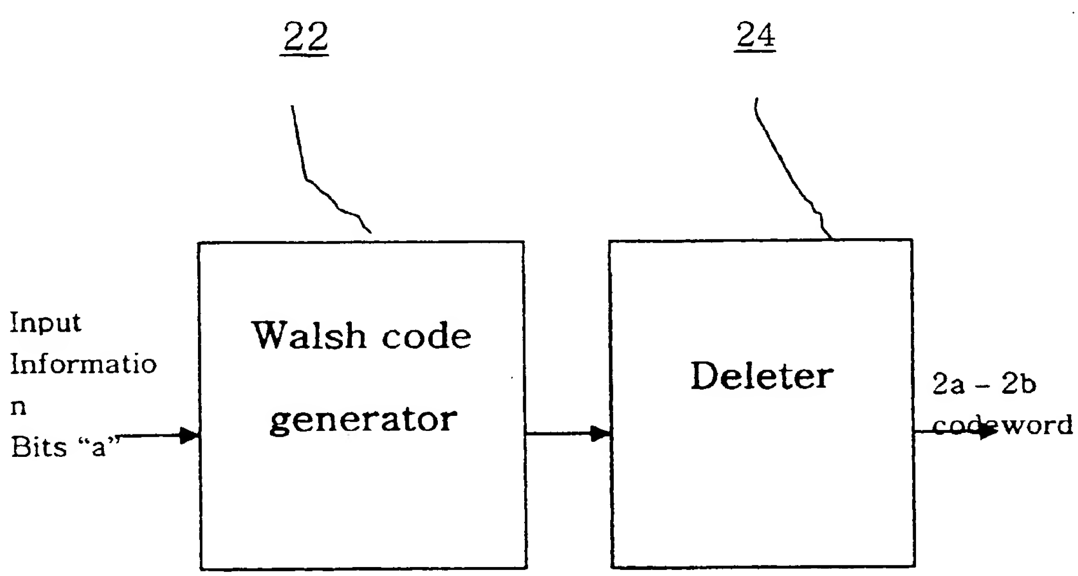
(81) Designated States *(national)*: CN, DE, US.

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: BINARY LINEAR CODES GENERATION APPARATUS AND METHOD USING ORTHOGONAL CODES FOR COMMUNICATION SYSTEM



(57) Abstract: This invention related to an apparatus and method for generating a linear block code by using an orthogonal code set. A transmitter transmits a codeword instead of information bits representing an information. The codeword length is longer than the information bits length. The length of codeword L can be predetermined based on permitted error rate and transmission space of the codeword in a communication frame. That means a coding rate is predetermined in a communication system. An orthogonal code set, the orthogonal code length is 2^a, can be defined. The orthogonal code length 2^a is a least value larger than the codeword length L. A codeword having length L is generated by deleting "c" predetermined symbols of the orthogonal code. The transmitter transmits one codeword related to the information bits. A receiver receives the codeword transmitted by the transmitter and decodes the received codeword.

WO 02/19534 A1

BINARY LINEAR CODES GENERATION APPARATUS AND METHOD USING ORTHOGONAL CODES FOR COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates generally to a apparatus and method for generating a optimum codeword. The codeword is transmitted by a transmitter and received by a receiver decoding the codeword.

2. Description of the Related Art

As the receiver is known the transmission method and encoding method of the transmitter, the receiver can receives the codeword and decodes the codeword as original information bits transmitted by the transmitter. If a communication channel has very low error probability condition, the information bits can be transmitted by itself. But if the communication channel has high error probability condition or the information bits are very important bits, the information bits are transmitted after encoding. There are several codes as linear code and non-linear code. The linear code can be generated from combination of basis codes.

The purpose of transmitting codeword generated by encoding the information bits is recovering the information bits from errors can be occurred during the transmission by way of decoding in the receiver. There are several method of coding /decoding as block code, convolution code and Turbo code. Generally if they use same coding/decoding method, the error correction probability is high when a coding rate is low. That mean if information bits are short, the error correction probability is high. If the coding rate is low, complexity of encoder and decoder is increased and

transmission throughput is decreased.

Generally transmission time interval of a frame is predefined in a communication standard text. A transmission data rate is determined by the number of data to be transmitted in the transmission time interval of the frame. Therefore in real communication system, the coding rate of certain information bits is determined according to the transmission time interval, data rate, modulation method, delay time, complexity and appropriate error rate.

It can be called (2^a, a) linear block code then the number (length) of binary information bits is "a" and the number (length) of generated codeword is 2^a. The performance of the linear block code is defined by a minimum distance (d_{min}) of the codewords generated by the linear block code. Minimum distance is a minimum value achieved by counting "1" in each codeword which can be generated by the linear bock code. As minimum distance is large, the probability of error correction is high. But the minimum distance is limited. A block code have most large minimum distance than other block code's is called optimum code at certain length. In real communication system, it is recommended to use optimum code and low complexity of encoder and decoder. If coding rate is determined in a communication system, it is needed to research to find a code have most large minimum distance out of all codes at the given coding rate. The method to find optimum code out of all code is call full search method. But using full search method, it substantially can't find optimum code for its length is long. As a code length is long, the kinds of code are increased by exponentially. A Walsh code, a kind of orthogonal code having a characteristics of orthogonality with each codeword was known. The length (column) of the Walsh code has multiples of two (2^a) and the sort of its codeword has multiples of two (2^a) also. ("a" is a positive integer) Walsh code is known as (2^a, a) linear block code. The Walsh code, a codeword, can be decoded by inverse fast Hardarmard transform (IFHT) as a kind of decoding method. The complexity of the IFHT decoder is very low than other decoding method.

SUMMARY OF THE INENTION

This invention describes a method to find optimum code in a linear binary code (2^a- 2^b, a) when the length of information is "a" and the length of codeword(coded bits) is 2^a- 2^b (the "b" is smaller than the "a").

This invention provides apparatus and method for generating and/or decoding the proposed optimal code.

It is, therefore, an object of this invention to provide an apparatus and method of encoding (2^a- 2^b, a) linear block code.

It is further another object of present invention to provide an apparatus and method of generating (2^a- 2^b, a) linear block code.

It is still another object of present invention to provide an apparatus and method of decoding (2^a- 2^b, a) linear block code.

According to one aspect of present invention, there is provided a method comprising the step of; generating Walsh code related to an information bits which have length "a"; determining deleting bit positions in the Walsh code for deleting 2^b bits; and deleting 2^b bits located at the deleting bit positions; wherein the deleting bit positions are defined by combination of "b" number of linear independent basis and the first bit of the Walsh code.

According to another aspect of present invention, there is provided an apparatus encoding an information bits, comprising; an Walsh code generator for generating a Walsh code which length is determined by length of the information bits; and a deletor for deleting predetermined 2^b bits including first bit out of the Walsh code.

According to still another aspect of present invention, there is provided an

apparatus for decoding comprising; a receiver for receiving a coded bits generated by deleting 2^b bits located at deleting bit positions in a Walsh code from a transmitter; an inserter for inserting 2^b bits at the deleting bit positions; and an inverse fast Hardarmard transformer for decoding the output of the inserter.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram representing a Walsh code structure which have row and column. The index, number of raw, is information bits.

Figure 2 is a diagram representing an encoder of present invention.

Figure 3 is a diagram representing an decoder of present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODYMENT

Throughout this invention, when it is needed to transfer information from a transmitter to a receiver, assumes transmitter and receiver are engaged to represent the information with correspond information bits. Generally, the transmitter transmit a coded bits (codeword) generated by encoding the information bits. The transmitter includes an encoder which have Walsh code generator for inputting the information bits and generating Walsh code, and a deletor for deleting predetermined bits located at the deleting bit positions in the Walsh code. The remained bits after the deletion are coded bits (codeword) which will be transmitted on wired line or radio channel. Encoder and decoder of present invention can be used, but not limited, in the wired communication, satellite communication, GSM (Global System for Mobile), DCS (Digital Cellular System), PCS (Personal Cellular System), IMT-2000 system, cdma-2000 system WCDMA (Wideband Code Division Multiple Access), UMTS (Universal Mobile Terrestrial System) or other mobile systems. When the length of information bits determined, a method for searching optimum code will be described. If all kinds of information to be transferred are equal to or less than 2^a, the length (number) of binary information bits are "a". This invention describes a method for search optimum linear

block code (2^a- 2^b, a) when the length of coded bits (codeword) are 2^a- 2^b and the information bits are "a" ("a" greater than "b").

Orthogonal code is the optimum code of which length (column) is 2^a and number of codeword (row) is 2^a. The orthogonal code, Walsh code, is represented as a matrix having 2^a column and 2^a row. This invention consider that deleting 2^b bits out of the 2^a bits, orthogonal code, to generate optimum code of 2^a- 2^b length. It can't generate optimum code by carelessly deleting 2^b column of the Walsh code. For generate optimum code, selecting "b" binary linear independent basis of which length is "b", determining deleting bit positions by obtaining decimal numbers corresponding to binary numbers acquired from all sort of combination of the basis code having length b. The basis are binary added at the combination.

An example of this invention, assume "a" is 5 and "b" is 3 ofr describe a method of searching (24, 5) block code. Figure 1 is the Walsh code having 32 column and row. As :b: is 3, select three binary linear independent basis (001, 010,100) which length is "3". All combination of the binary linear independent basis is (001, 010, 011, 100, 101, 110, 111) deleting bit positions are all combination of the binary linear independent basis and (000). Decimal number of the deleting bit position are 0, 1, 2, ... 7. Therefore, deleting 0 to 7 column of the Walsh code. Underlined bits of Walsh code in Figure 1 represent deleting bits. Minimum distance of the (24, 5) block code generated by above method is 12. It is a optimum code of length 24 code.

Figure 2 represent an encoder (20) of (2^a - 2^b, a) linear block code obtained by above method. An information bits "a" (the length of "a" is 5) are inputted in the Walsh code generator (22). The Walsh code generator (22) can generates 2^a (=32) numbers (row) of Walsh codes correspond to an information bits. The Walsh code generator (22) outputs one Walsh code (the length of Walsh code is 32) to a deleter (24) in response to the input information bits. The deleter (24) controlled by a controller (not depicted) deletes 2^b (=8) bits positioned at the deleting bit positions (0,

1, 2, ...7). The encoder (20) generated 2^a- 2^b (=24) length of coded bits (codeword) upon respond to inputting the information bits length "a" (=5). The coded bit 0 (1) is converted as +1 (-1) for radio transmission. A digital signal processor (DSP) software also ca be used to implement the same function as the encoder (20). If a microprocessor have a memory storing the coded bits (codeword) generated as above description, can output correspond coded bits upon respond to the information bits. The Walsh code of figure 1 can be obtained from Walsh code basis, (for example,
01010101010101010101010101010101,
00110011001100110011001100110011,
00001111000011110000111100001111,
00000000111111110000000011111111,
00000000000000001111111111111111).
Therefore, upon respond to the information bits which can be represented by a combination of a basis code (00001, 00010, 00100, 01000, 10000), the DSP or microprocessor storing the Walsh code basis in its memory can generates correspond Walsh code by bit by bit adding the Walsh code basis correspond to the basis code. The DSP or microprocessor outputs encoded bits (codeword) except the bits located at the deleting bit positions.

Figure 3 represents a decoder (30) decodes a received signal (codeword) from the encoder (20). 2^a - 2^b (=24) number of received bits are inputted in a inserter (32). The inserter (32) inserting 2^b (=8) number of zero bits ("0") in the deleting bit positions (in front of the received signal). The signal including 2^b number of "0" in the received signal is inputted in a inverse fast Hardarmard transformer IFHT (34). The IFHT (34) outputs 2^a (=32) number of correlation values by performing inverse Hardarmard transform. The correlation values are inputted in a comparator (36). The comparator (36) compares the correlation values each other and determines an index corresponded to the largest correlation value. The index correspond to the largest correlation value is a decoded information bits.

The decoder of figure 3 can be implemented by a software algorithm. The

actual values of this invention are only for example. Anyone who has his technical field is the same as this invention can change the values as his needs. When the value "a" greater than "b", the concept of this invention can be used at other modifications of this invention. And if select other linear independent basis codes for determining the deleting bit positions, the deleting bit positions of the encoder will be different from the example of above description. Hence the inserting bit positions also different.

Assume that the transmitter uses (24, 5) block code and transmits "01000" (=16) as information bits, the Walsh code generator (22) generates corresponding Walsh code, index number 16, (0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1) which length is 32. The deleter (24) deletes front part 8 bits out of the Walsh code, then outputs 24 bits codeword (coded bits; 111111110000000011111111). The transmitter converts 0 bit to +1 (1 bit to –1) of the codeword and modulates the converted signal by using BPSK, QPSK, 8PSK or QAM for transmitting to air. The receiver receives the 24 signals. The inserter (32) inserting 8 bits in front of the 24 signals and outputs 32 signals including the 8 inserted bits and the 24 received signals. The IFHT (34) performs inverse Hardarmard transform using the output of the inserter and outputs 32 correlation values. The comparator (36) compares the 32 correlation values and outputs the largest correlation value out of the 32 correlation values. The receiver (30) determines an index (01000) as decoded bits correspond to the largest correlation value.

As above description, this invention provides a method for search optimum code of (2^a - 2^b, a) block code and simple encoder and decoder for real communication system. This invention can be directly applied at an encoder/decoder of a transmission format combination indicator in the narrow band time division duplex system using 8PSK modulation.

CLAIMS

1. An encoder for receiving input information bits which length is "a" and outputting $2^a - 2^b$ (a>b) number of coded bits, comprising;

a Walsh code generator for generating 2^a length of Walsh code in response to "a" information bits; and

a deletor for deleting 2^b number of bits located in the front part of the Walsh cod.

2. The encoder of claim 1 wherein said Walsh code generator storing the Walsh code in a memory.

3. The encoder of claim 1 wherein said Walsh code generator having Walsh code basis and generating codeword by combining the Walsh code basis corresponded to the information bits.

4. An encoder for encoding input information bits which length is "a" and outputting $2^a - 2^b$ (a>b) number of coded bits, comprising;

a Walsh code generator for, upon response to the information bits, generating a Walsh code which length is 2^a by using a Walsh code basis; and

a deleter for deleting 2^b bits positioned at each decimal numbers obtained from binary numbers acquired from all sorts of combinations of a basis codes having length "b".

5. An decoder for decoding $2^a - 2^b$ received signal which is encoded by an encoder encoding "a" length of information bits and outputting the $2^a - 2^b$ (a>b) length of coded bits, comprising;

an inserter for inserting 2^b number of "0" bits in front of the received signal then outputting 2^a signal; and

an inverse fast Hardarmard transformer for performing inverse Hardarmard

transform to the output signal of the inserter and outputting 2^a number of correlation values; and

a comparator for comparing the correlation values and determining greatest correlation value out of the 2^a number of correlation values;

wherein the decoder determines an index corresponded to the greatest correlation value as the information bits.

6. A method for encoding input information bits having length "a" and outputting 2^a - 2^b coded bits, comprising the steps of;

generating Walsh code corresponding to the information bits; and

deleting 2^b number of bits located at the front part of the Walsh code.

7. The method of claim 6 wherein the Walsh code is generated by bit by bit adding of Walsh code basis stored in a memory.

8. A method for encoding input information bits which length is "a" and outputting 2^a - 2^b (a>b) number of coded bits, comprising the steps of;

generating, upon response to the information bits, a Walsh code which length is 2^a by using a Walsh code basis; and

deleting 2^b bits positioned at each decimal numbers obtained from binary numbers acquired from all sorts of combinations of a basis codes having length "b".

9. A method for decoding 2^a - 2^b received signal which is encoded by encoding "a" length of information bits and outputting the 2^a - 2^b (a>b) length of coded bits, comprising the steps of;

inserting 2^b number of "0" bits in front of the received signal then outputting 2^a signal; and

performing inverse Hardarmard transform to the output signal of the inserter and outputting 2^a number of correlation values;

comparing the correlation values for searching the greatest correlation value

out of the 2^a number of correlation values; and

determining an index corresponded to the greatest correlation value as the information bits.

FIGURE 1.

Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
00000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00001	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
00010	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
0011	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
00100	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
00101	0	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0
00110	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0
00111	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0	1
01000	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
01001	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0
01010	0	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0
01011	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1
01100	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
01101	0	1	0	1	1	0	1	0	1	0	1	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	0	1	0	1
01110	0	0	1	1	1	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	0	1	1
01111	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	0
10000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10001	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
10010	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
10011	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1
10100	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
10101	0	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1
10110	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1
10111	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0
11000	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
11001	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1	0	1	0	1	0	1
11010	0	0	1	1	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1
11011	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	0	1	1	0	0	1	1	0
11100	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1
11101	0	1	0	1	1	0	1	0	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	0	1	0	1	1	0	1	0
11110	0	0	1	1	1	1	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	1	1	1	1	0	0
11111	0	1	1	0	1	0	0	1	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0	1

FIGURE 2.

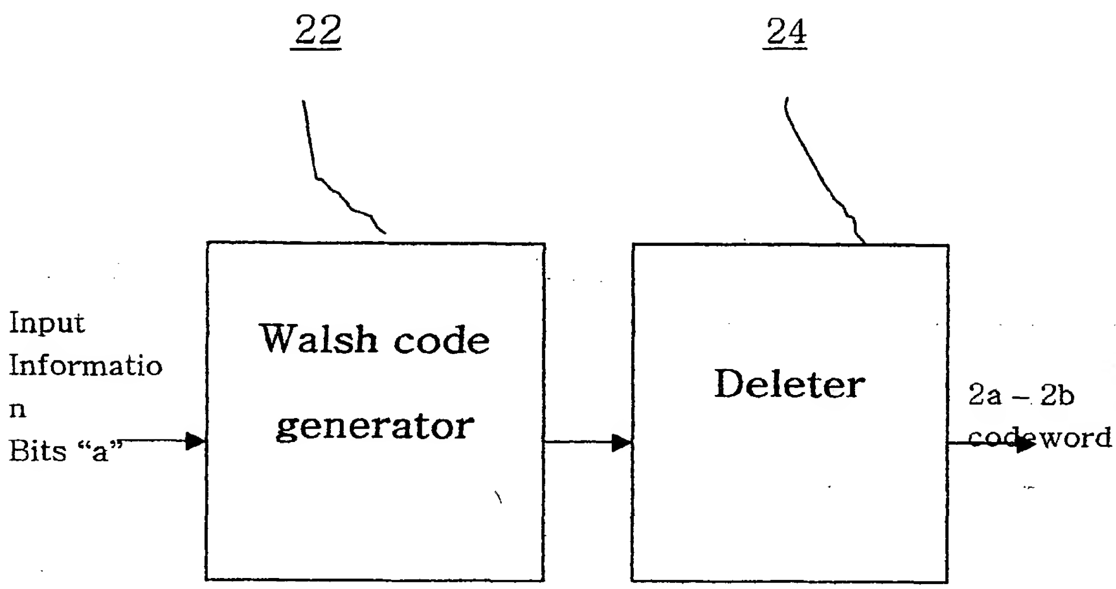
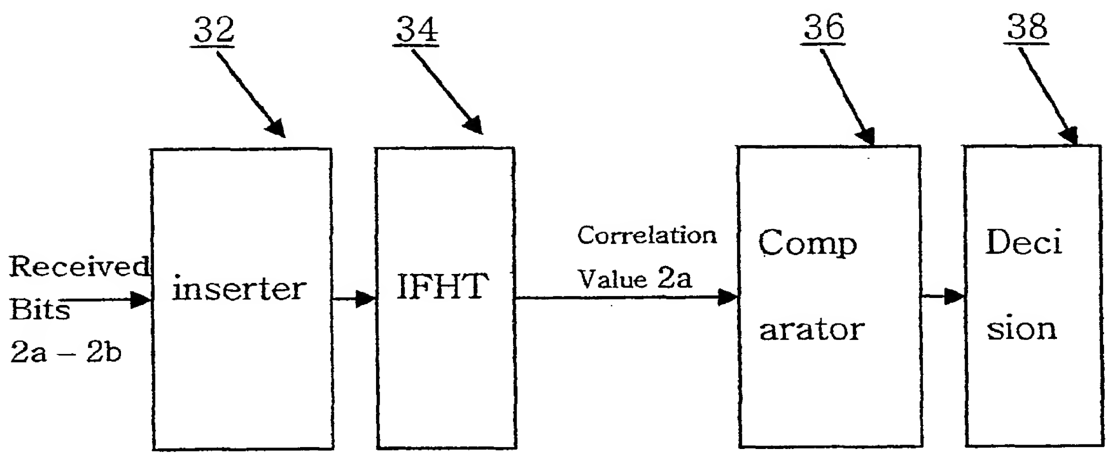

22
24
Input
Informatio
n
Bits "a"
Walsh code
generator
Deleter
2a – 2b
codeword

FIGURE 3.


32
34
36
38
Received Bits 2a – 2b
inserter
IFHT
Correlation Value 2a
Comp arator
Deci sion

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/01399

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H03M 7/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC 7 H03M H04L H03K

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean patents and applications for patent since 1975
Korean utility model registrations and applications therefor since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 291 961 A2 (CSELT Centro Studi e Laboratori Telecomunicazioni S.p.A.) 23 November 1988 see abstract	
A	EP 0 907 256 A2 (David HACCOUN, Naim BATANI, and Christian CARDINAL) 07 April 1999 see abstract	
A	EP 0 642 228 A2 (Mitsubishi Denki Kabushiki Kaisha) 08 March 1995 see abstract	

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 NOVEMBER 2001 (30.11.2001)	07 DECEMBER 2001 (07.12.2001)

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea	SEO, Cheon Seok
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5724

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR01/01399

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0 291 961 A2	23 November 1988	IT 6743887	20 May 1987
EP 0 907 256 A2	07 April 1999	CA 2249095AA	02 April 1999
		DE 907256R2	07 April 1999
EP 0 642 228 A2	08 March 1995	AU 6456094 A1	27 January 1995
		DE 1056211R1	29 November 2000
		JP 3058796 B2	04 July 2000
		US 5642365 A	24 June 1997